

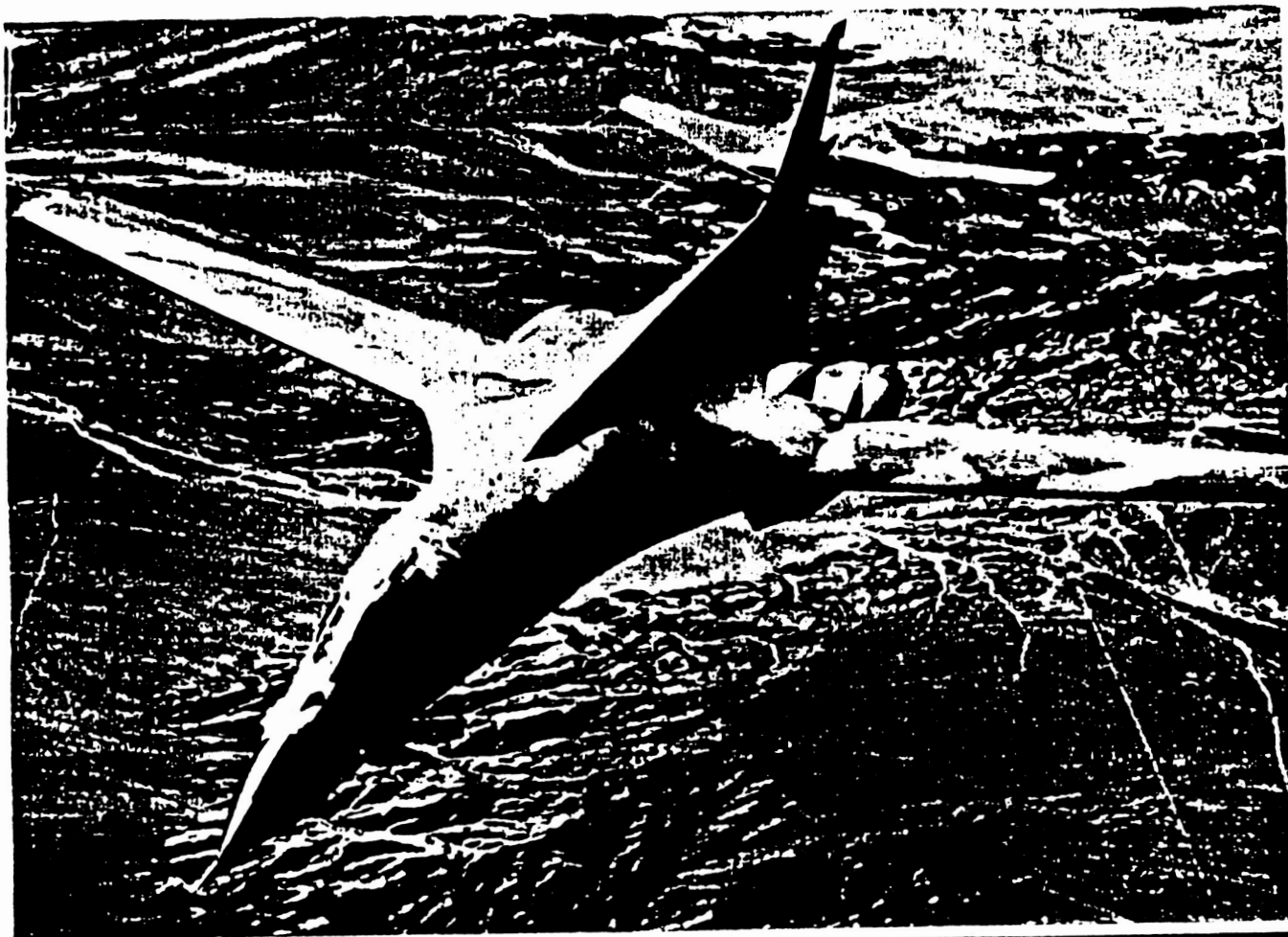
N 89 - 22943

**INCREASING  
MARKETABILITY  
AND  
PROFITABILITY  
OF PRODUCT LINE THRU  
PATRAN & NASTRAN**

**ART HYATT  
DEUTSCH METAL COMPONENTS**

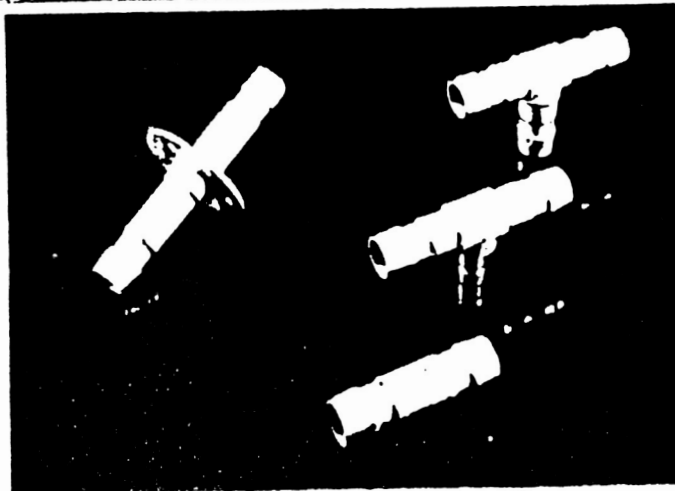


14800 S. Figueroa, Gardena, CA 90248 (213) 323-6200



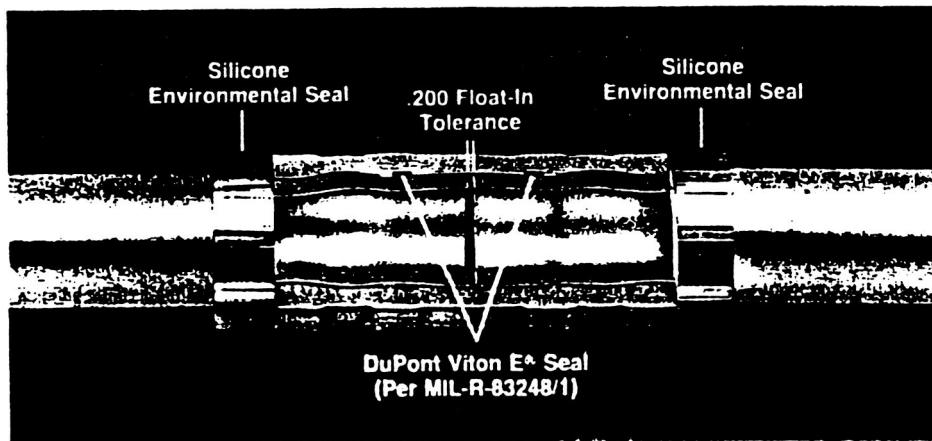
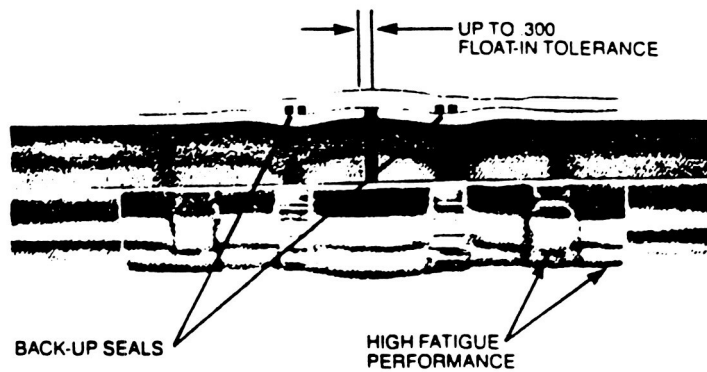
## INTRODUCTION

Deutsch Metal Components Manufactures advanced Fluid System Components for the Aerospace, Marine, and Petrochemical Industries. These fittings permanently connect Pipe and/or Tubing Systems and are recognized under the trade names, Permaswage® and Pyplok®.



*The above photo shows the B-1B Bomber. This is one of the many types of aircraft that uses the Deutsch fittings.*

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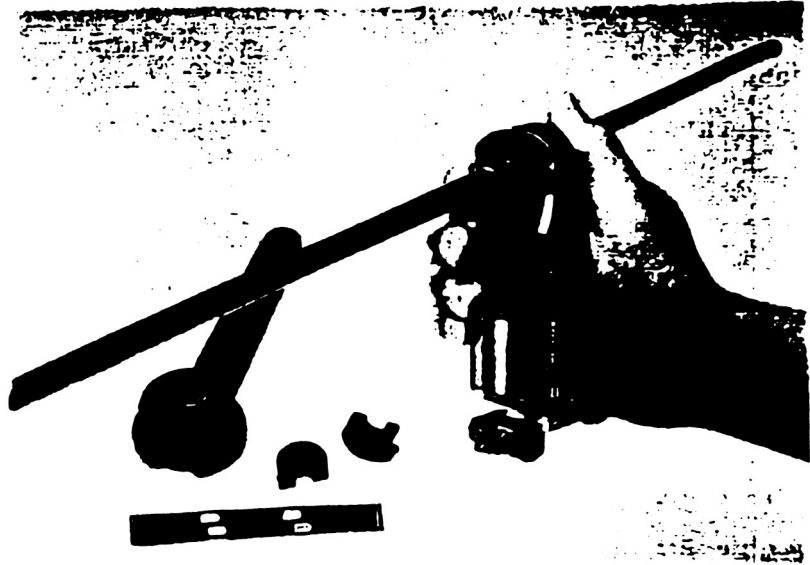


## FITTING DESIGN

The upper photo shows a cut-a-way Permaswage® fitting connecting together two pieces of tubing. The fitting is slid into the tubes and then swaged or crimped resulting in a permanent light weight connection. Completed connections feature 2 seals on each side of the fitting. One is a positive metal-metal seal the other is a silicone back-up seal.

The lower photo shows the Pyplok® fitting and pipe connecting system which is similar in concept to Permaswage®, but is used on piping systems in the Ship Building/Ship Repair and Petrochemical Industries. Both systems are available in the standard Pipe/Tube fitting configuration, such as; Coupling, Tees, Elbows, Reducers, etc.

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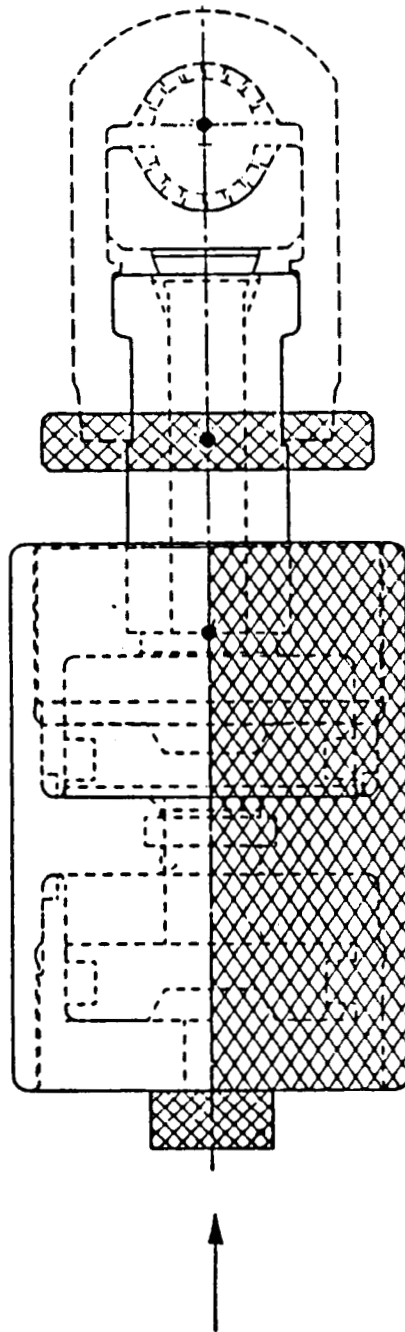


## SWAGE TOOL

This Swaging Tool is one of the models of the product line which is the **subject** of the paper. There are 6 different models in the product line: Model 5, 10, 20, 30, 40, and Model 55. For simplicity in this paper only one model will be discussed. The swaging tool which performs the swaging or crimping of these fittings is hydraulically actuated.

The photo above shows this tool in operation. The upper left hand slide shows the top portion of the tool which contains a slotted Die which transforms axial or linear force from an axial direction to radially acting force. The next slide shows a detail of this Swage Die.



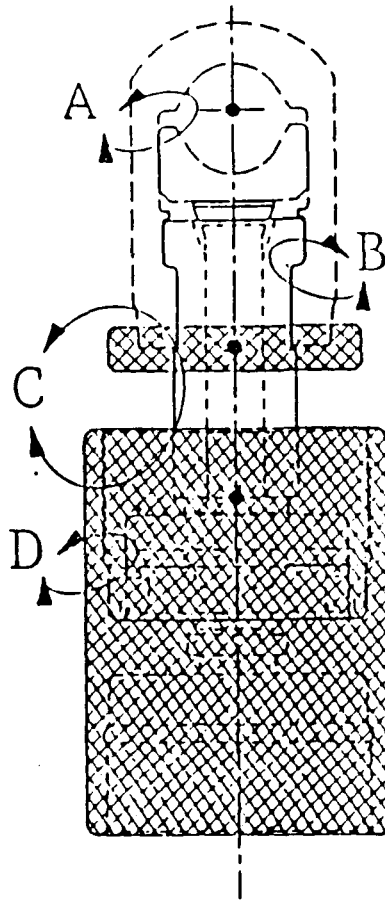


## EXISTING SWAGE TOOL

This slide shows the previous generation Tool. Pressurized oil enters at the bottom of the Tool and actuates the upper and lower pistons. These pistons force the lower die block against the slotted die which performs the swaging operation.

## DESIGN OBJECTIVE:

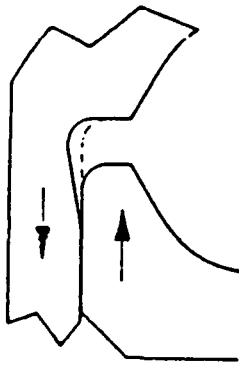
- To double the operational cycle life of the product.
- MCD felt that with some redesign of the tool, cycle life could be substantially extended.



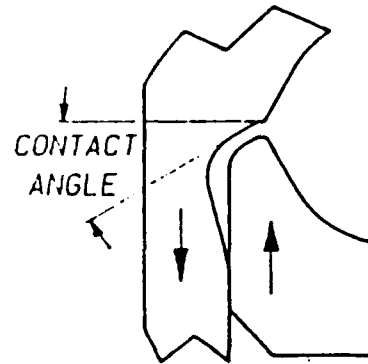
## **APPROACH USED TO ACCOMPLISH DESIGN OBJECTIVE**

- First, we submitted the existing Swage Tool to finite element analysis.
- Second, we determined the stress level required. This was based on a S-N Curve for the selected material and the operational cycle life requirement.
- Third, we concentrated our efforts on the highly stressed areas noted above.
- The first area analyzed was "A", the force on this area is 1/2 the total tonnage of the tool. Model 55 tool would have a total force of 110,000# of which 55,000# would be concentrated under worst conditions on this area.
- "B" is the reaction area.
- "C" reacts the forces thru the Strut and Top Cap back into the cylinder.
- "D" is the area where the Top Cap Threads mate the cylinder.
- These areas will be discussed in detail starting with "A".

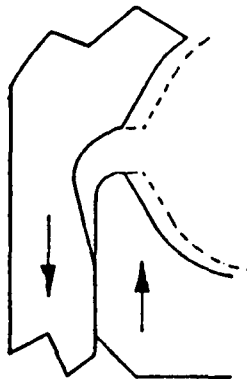
## AREA "A"



**1st** the radius was increased as shown above. This reduced the stress.

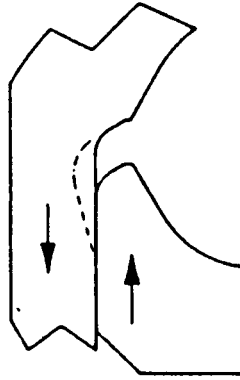


**2nd** the contact angle which was  $0^\circ$ , was changed. This reduced the stress some more. It should be noted at this point, different angles were tried from  $0^\circ$ - $45^\circ$ . The optimum angle was found to be  $30^\circ$ .

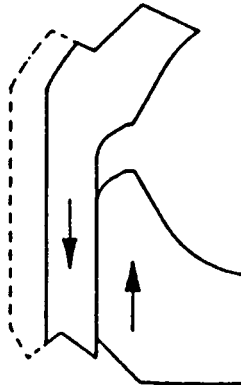


**3rd** the compression area was then made smaller. Again this reduced the moment and the associated stress.

## AREA "A" CONT.



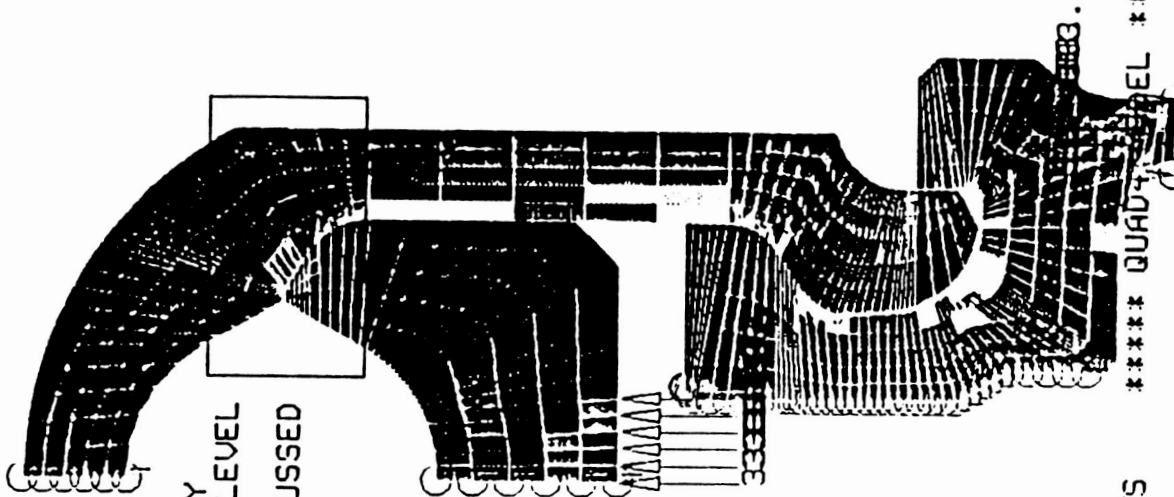
**4th** the contact area was reduced and the radius moved inward. This too lowered the stress level because the area across the high stress section was increased. The contact stress was performed by hand calculations.



**5th** the overall size was reduced. This was possible because the stress level had been substantially reduced in all areas.

The actual final FEA are shown on the following slides.

THIS IS A 1/2 MODEL OF  
SWAGE HEAD, DIE BLOCK AND  
CYLINDER. FORCES, BOUNDARY  
CONDITIONS AND STRESSES LEVEL  
ARE SHOWN.  
THE AREA PREVIOUSLY DISCUSSED  
IS SHOWN IN THE UPPER  
RIGHT HAND CORNER.

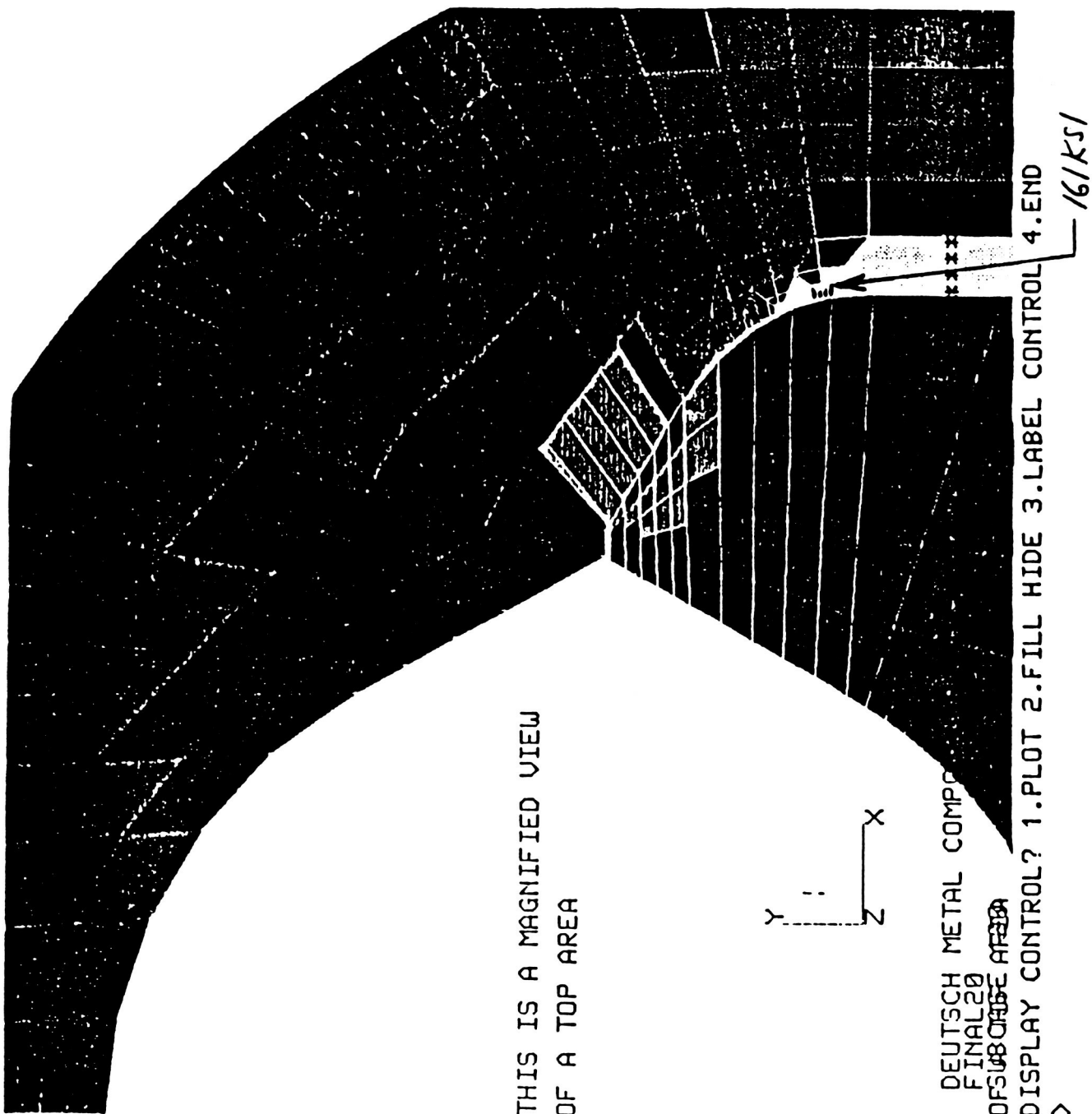


DEUTSCH METAL COMPONENTS \*\*\*\*\*  
FINAL20  
PS:GCHS:Y10B:CHARACTER TO SELECT  
WINDOW? 1.ZOOM 2.MOVE 3.CENTER 4.FIND 5.CORNERS 6.RESTORE 7.EXIT  
>

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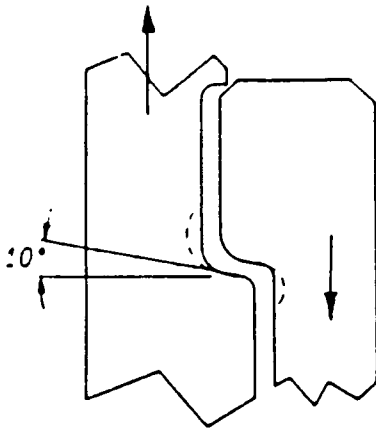
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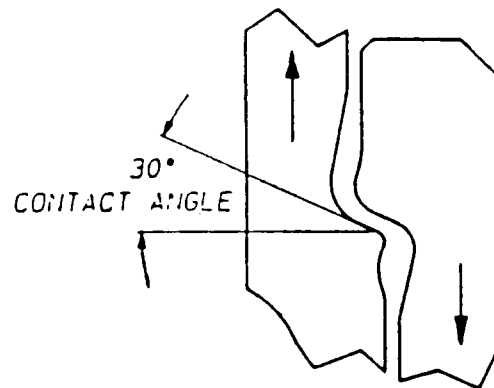


161294.	146723.	132152.	117581.	103011.	88440.	73869.	59299.	44728.	30157.	15586.	1016.	-13555.	-23126.	-42697.	-57267.	SUBC
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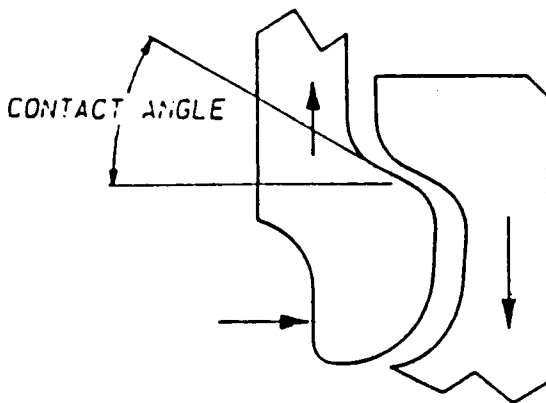
## THE SECOND AREA ANALYZED WAS THE REACTION PRESSURE AREA AT "B"



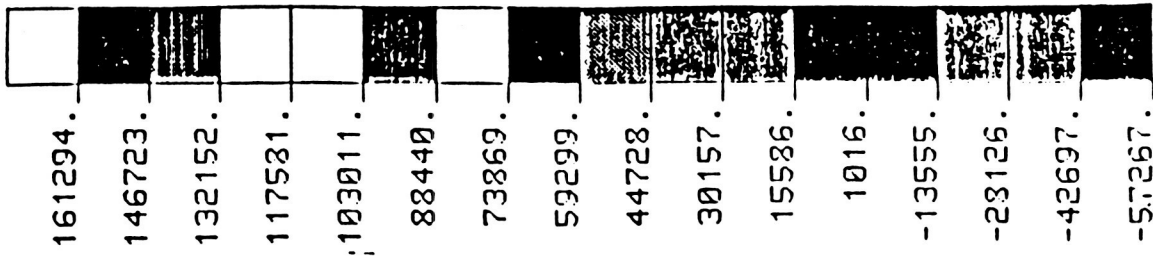
**1st** the radius was increased as shown above. This reduced the stress.



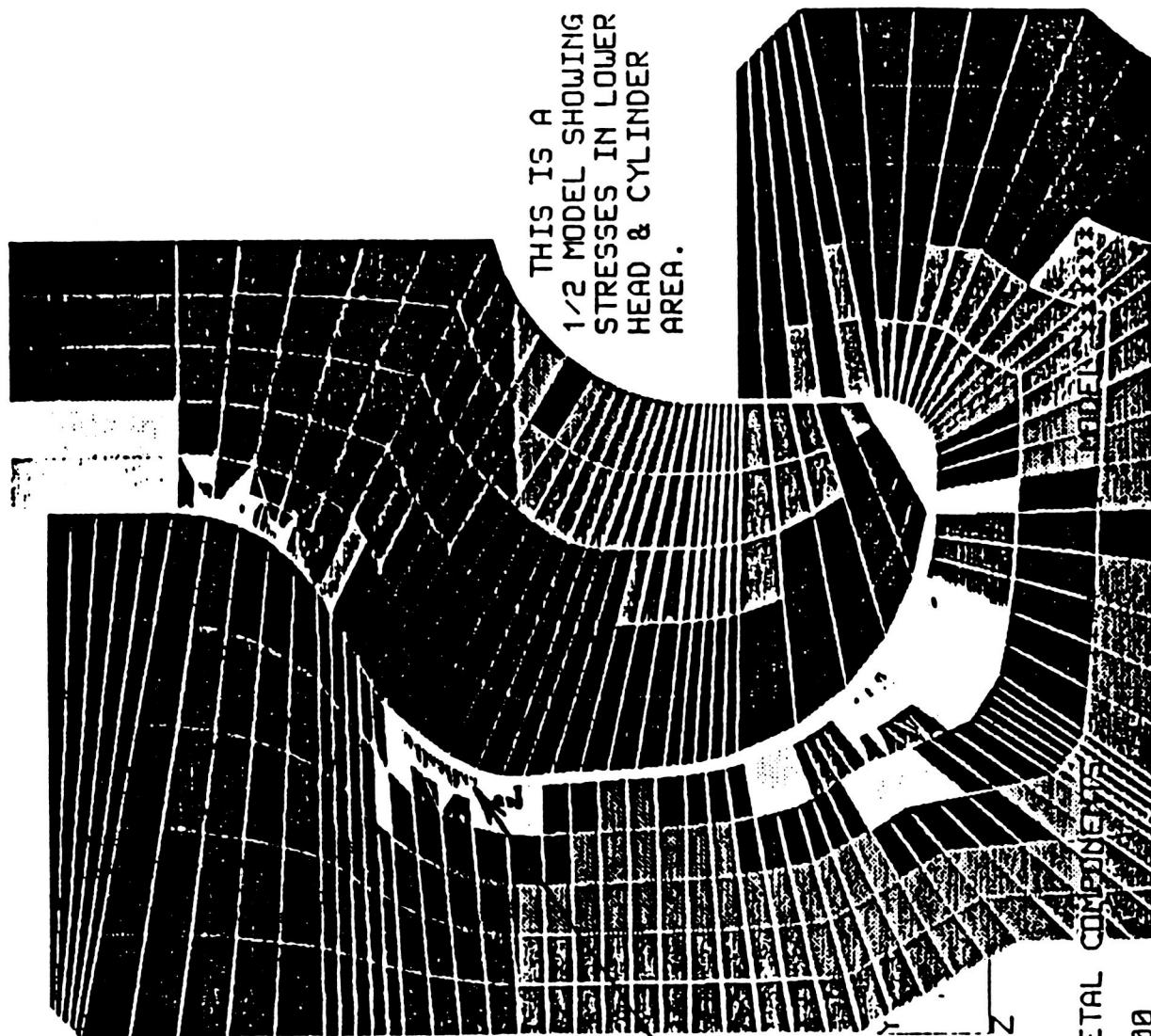
**2nd** the contact angle which was 10°, was changed to the optimum angle of 30°. The contact area was also changed again. Both of these changes lowered the stresses.



**3rd** The radii on both parts were made more generous & blended together. This again reduced the stress not only on the head, but also the cylinder. The result was a smaller and lighter cylinder and head. Actual FEA slides follow.



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161 KSI

DEUTSCH METAL COMPONENTS  
FINAL200

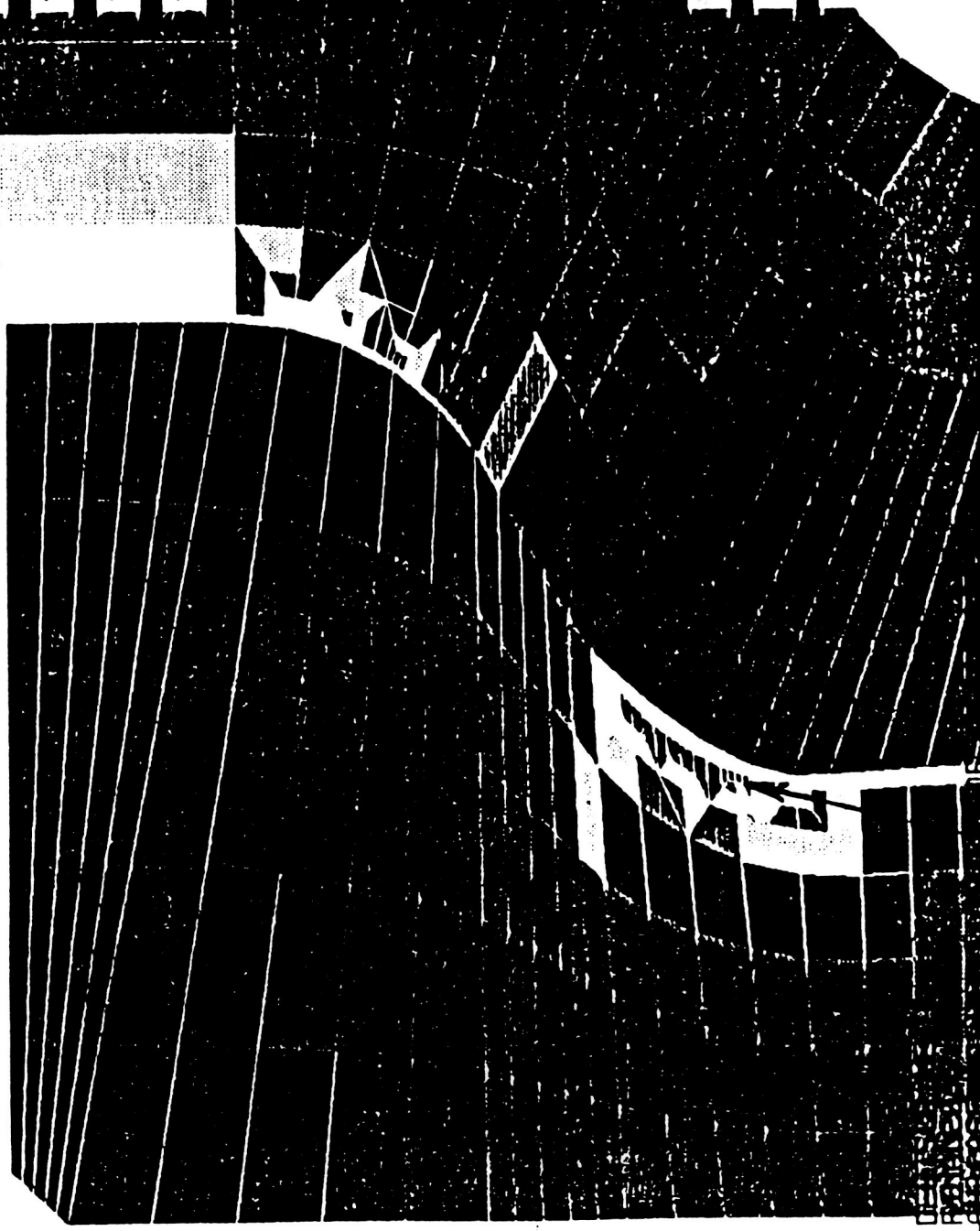
AFJ&CASE 100

DISPLAY CONTROL? 1.PLOT 2.FILL HIDE 3.LABEL CONTROL 4.END

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THIS IS A MAGNIFIED VIEW OF LOWER AREA



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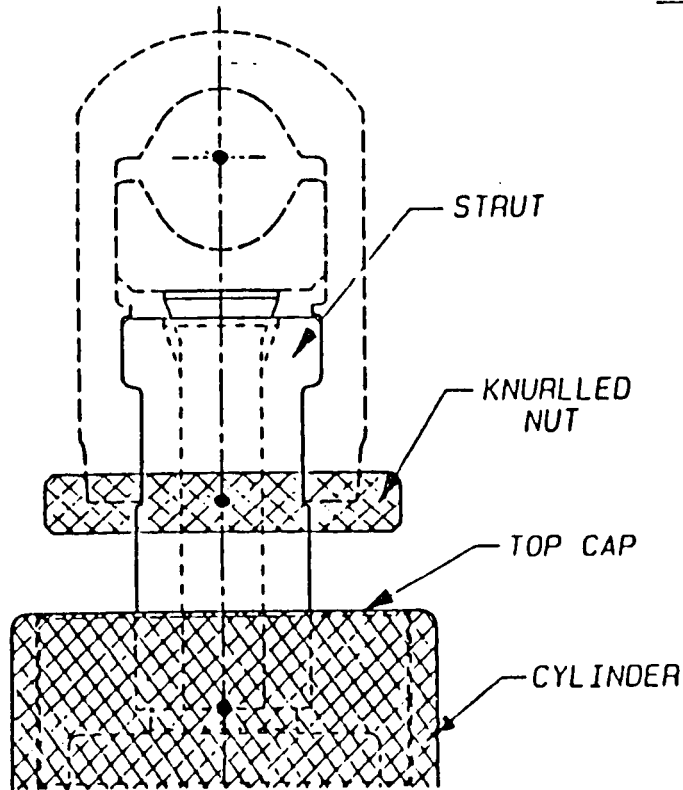
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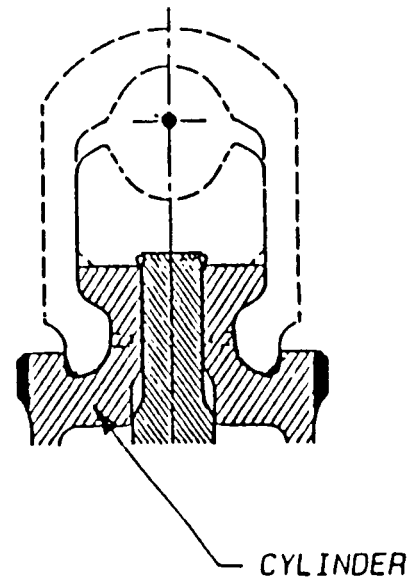
DISPLAY CONTROL? 1.PLOT 2.FILL HIDE 3.LABEL CONTROL 4.END

161 KSI

### 4 PIECE DESIGN

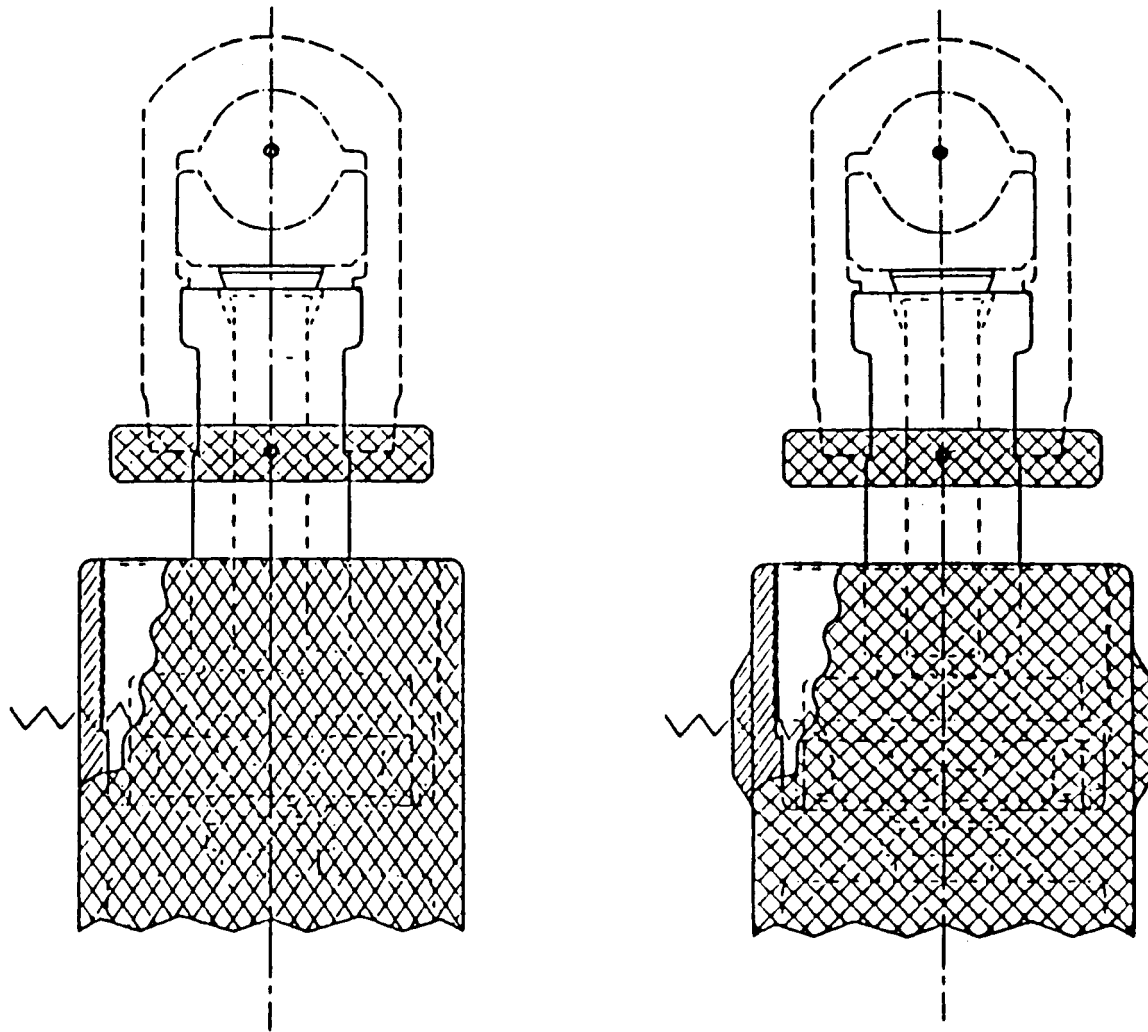


### 1 PIECE DESIGN



## **THE 3RD AREA ANALYZED WAS "C"**

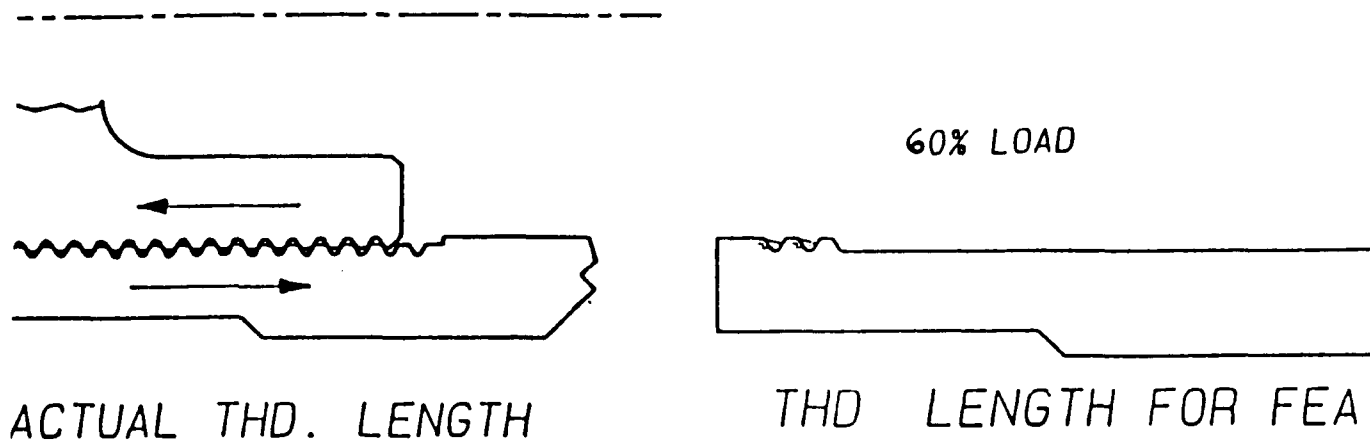
Knowing the forces involved it was an easy step to go from a (4) piece design, to a (1) piece design. The Strut, Knurled Nut, Top Cap and Cylinder were all made part of the Cylinder. This completely eliminated 3 parts. Finite elements again checked all high stress areas. The first analysis on the new design found several areas which had excessively high stress. Adding more material to the O.D. of the Cylinder and changing to a larger radius as shown resulted in acceptable stress levels.



## **THE 4TH AREA ANALYZED WAS “D”**

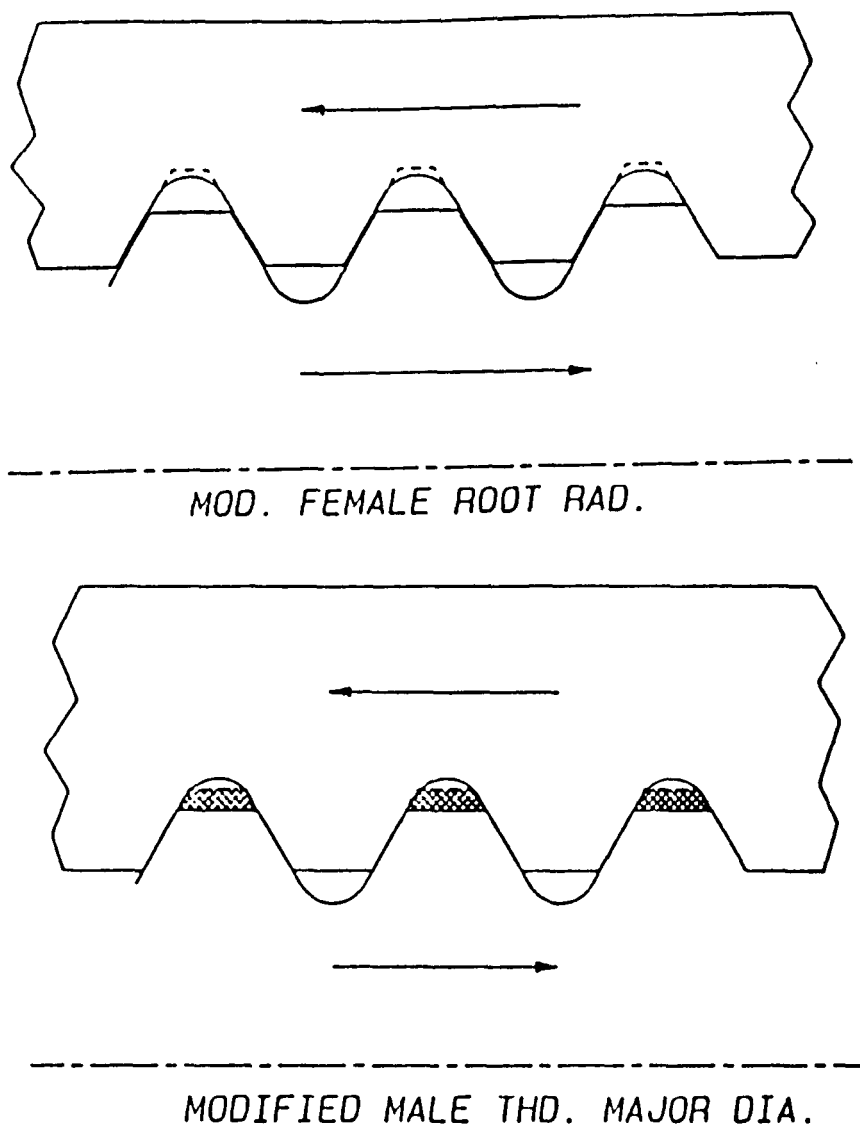
Lab tests showed that premature failure occurred at the 1st and 2nd thread area before we could reach the required cycle life. To solve the problem we made the following engineering modifications:

FIRST — More material was added to the O.D. of the cylinder where the failure occurred. Repeated tests showed very little improvement in the cycle life.

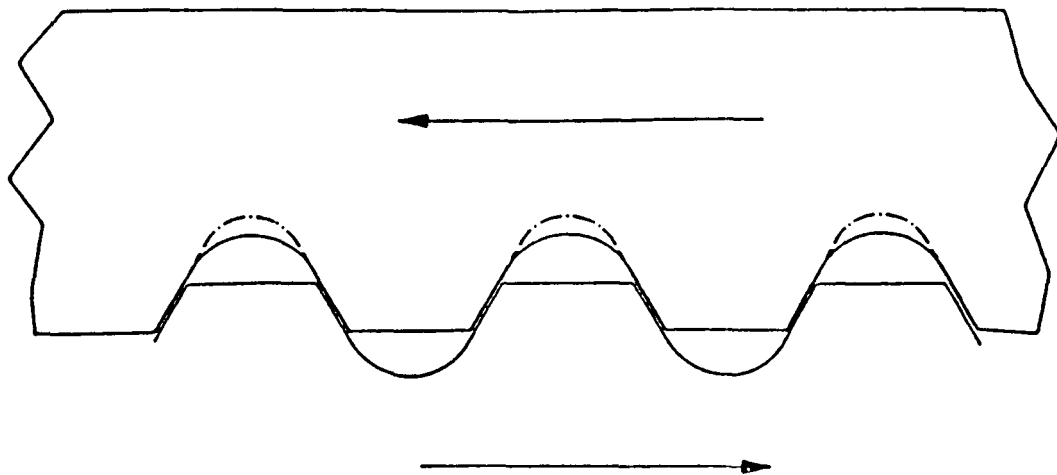


**SECOND —** The thread area was submitted to finite element analysis. The analysis was made for only 2 threads and was in 2 "D". 30% of the load was applied to each thread. This loading was applied because studies have shown that 60% of the load on a screw thread is concentrated on the first 2 threads.

FEA showed the weak area up immediately. It was, as expected, at the root of the thread.



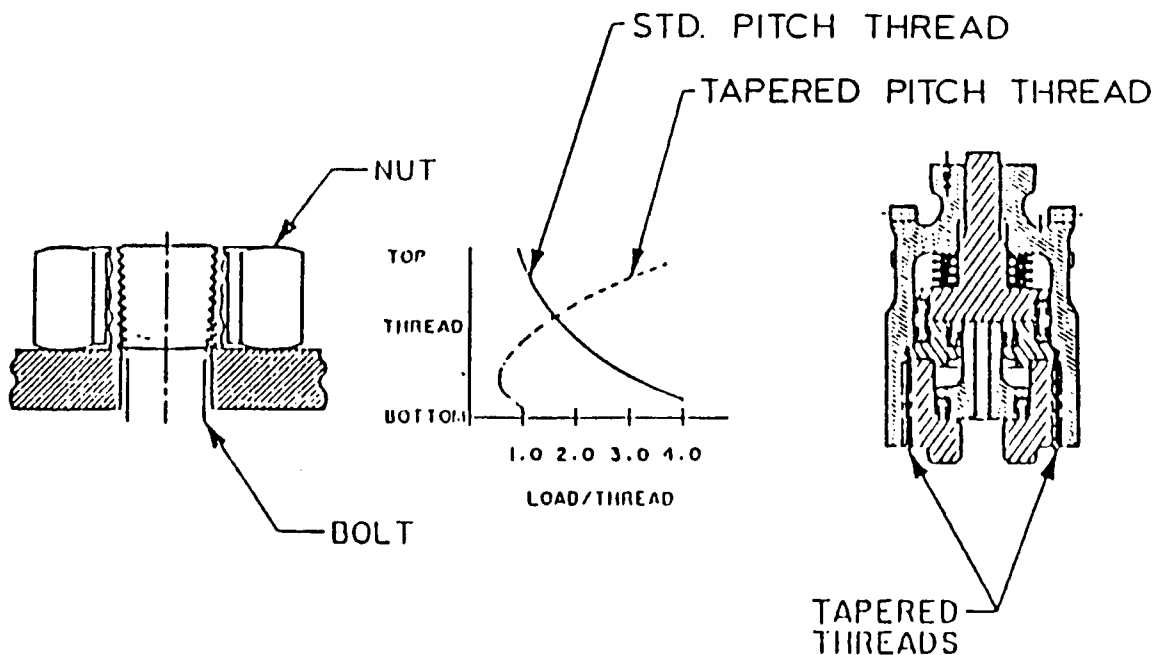
THIRD — Using this configuration and finite element analysis it was found that a modified UNJ thread with the thread root radius at the bottom of the cylinder (female) thread, as well as, on the male thread, greatly reduced the root stress level. This now became a modified thread because the standard UNJ thread only specified that the male have a root radius. With this female root radius it was also necessary to modify the O.D. of the male thread to prevent interference. Prototype models were then made, however, we still did not meet our required 100,000 cycle life requirement.



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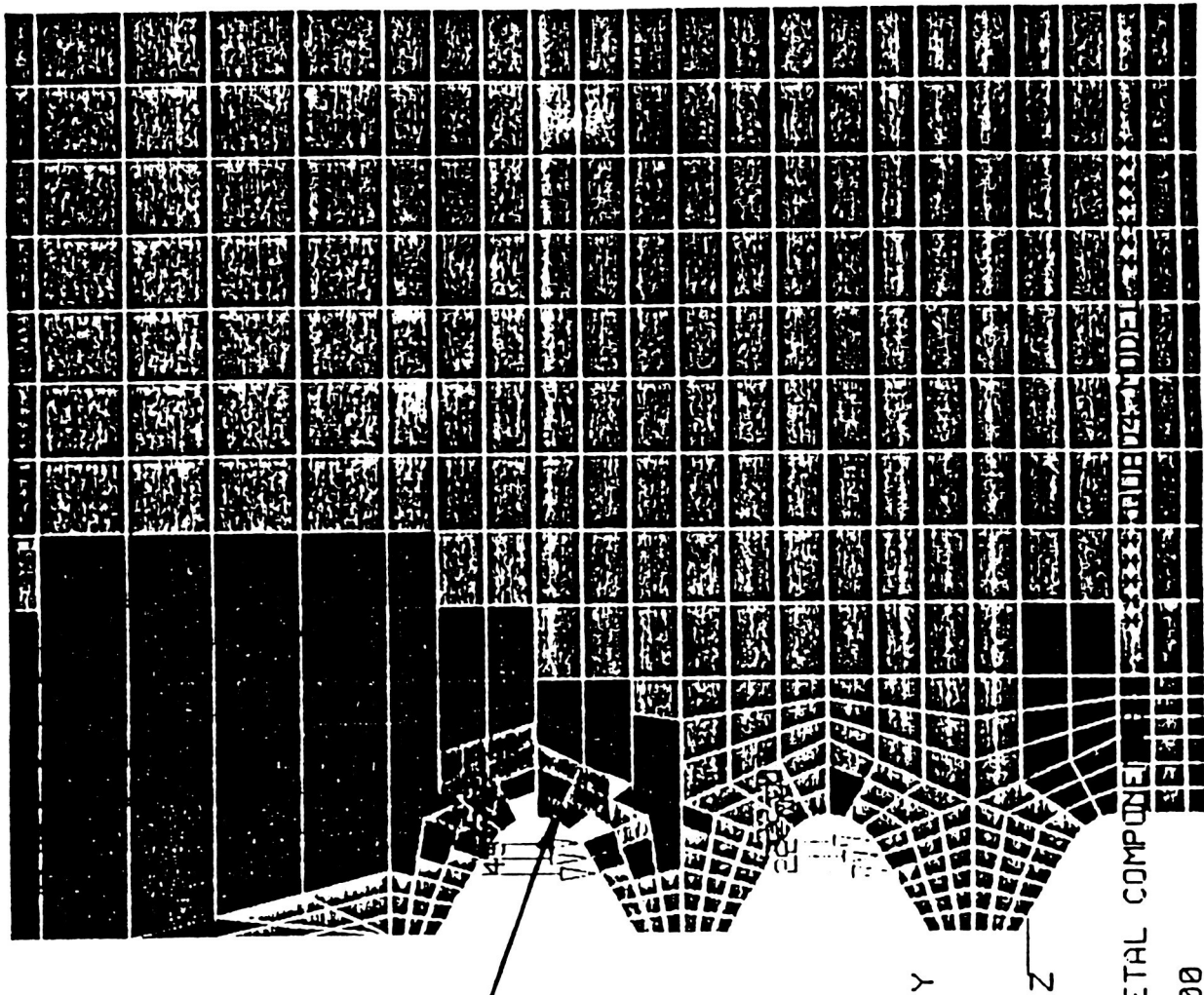
LARGER THAN STD. UNJ RAD.  
WITH SMALL CONTACT AREA

**FOURTH —** The next step was to return to FEA which showed that an increase in the root radius over and above the recommended UNJ radius would again lower stress levels. This was then tested and it was proven to add significantly to the cycle life. This solved the tool cycle life problem, however, because the area of contact was reduced the design could be a problem in manufacturing. If manufacturing made the slightest deviation in thread configuration failure could occur in the shear mode.



**FIFTH — TAPERED PITCH DIAMETER** As a final step, we found an article written for ASME on, "Effect of taper on screw-thread load-distribution". This article basically states that a .006 inch/inch taper of the pitch dia would result in a fairly distributed thread load. This design was first programmed on the CAD System and then subjected to finite element analysis. Results looked outstanding. Models were made and subject to test. The 100,000 cycle requirement was not only met but continuous cycle testing went well beyond the 100,000 cycles without any signs of failure in this area. It should be noted at this point that the cylinder wall was also reduced. The amount of reduction was almost 50% less than the original concept. This whole exercise proves that adding material does not necessarily make for a stronger product. The following slides show the final FEA results.

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SUBC



118ksi

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DEUTSCH METAL COMPONENT  
SCREW  
F03SUBCASE 100  
DISPLAY CONTROL? 1.PLOT 2.FILL HIDE 3.LABEL CONTROL 4.END  
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UNJ CYLINDER THREAD WITH  
TAPERED THREAD LOADS APPLIED

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Y

Z X

DEUTSCH METAL COMPONENTS

SCREW

FOR CHARACTER TO SELECT

WINDOW? 1.ZOOM 2.MOVE 3.CENTER 4.FIND 5.CORNERS 6.RESTORE 7.EXIT

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DEUTSCH METAL COMPONENTS \*\*\*\*\*

SCREW

FOR CHARACTER TO SELECT

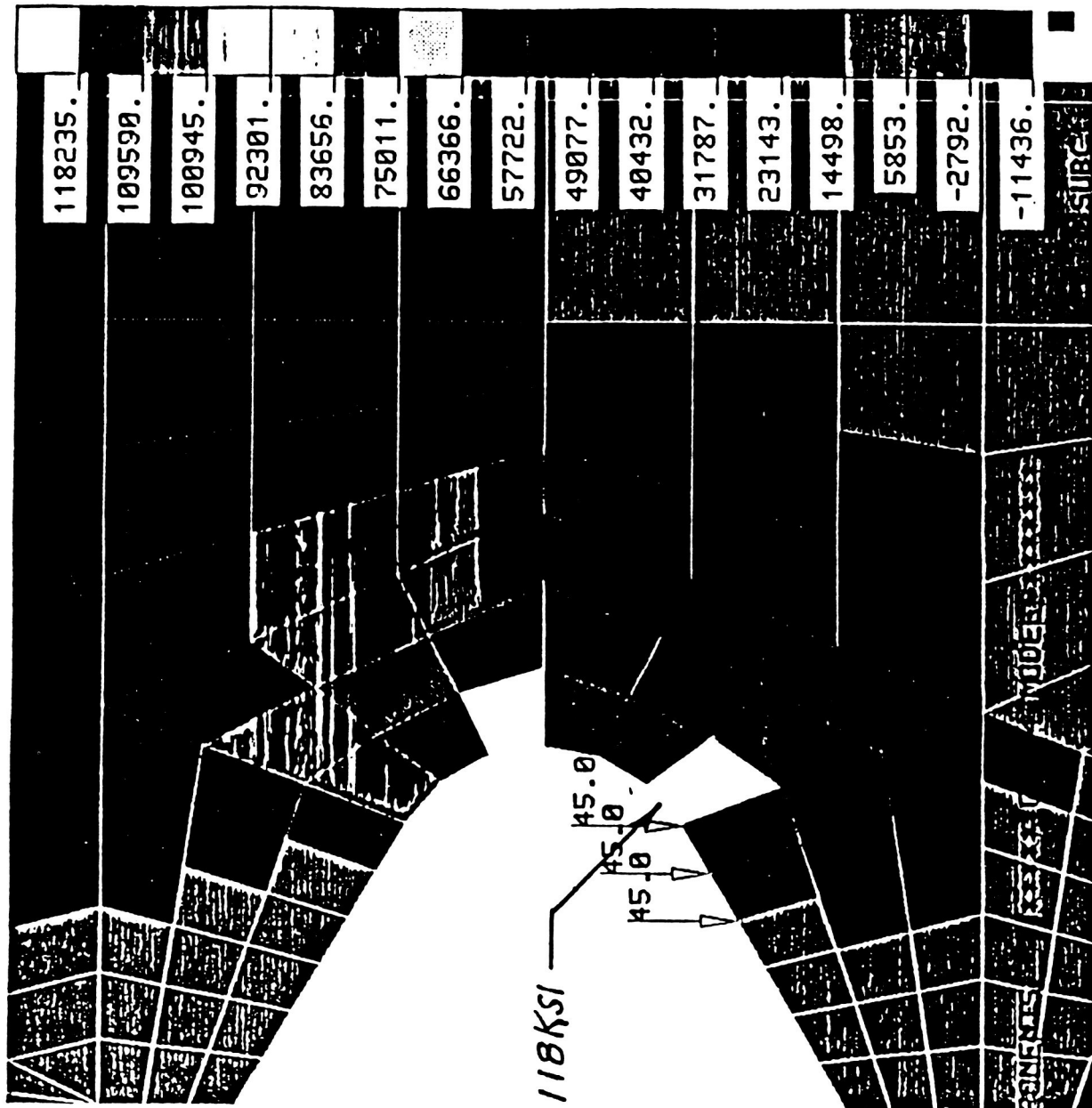
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SUBC

7.EXIT

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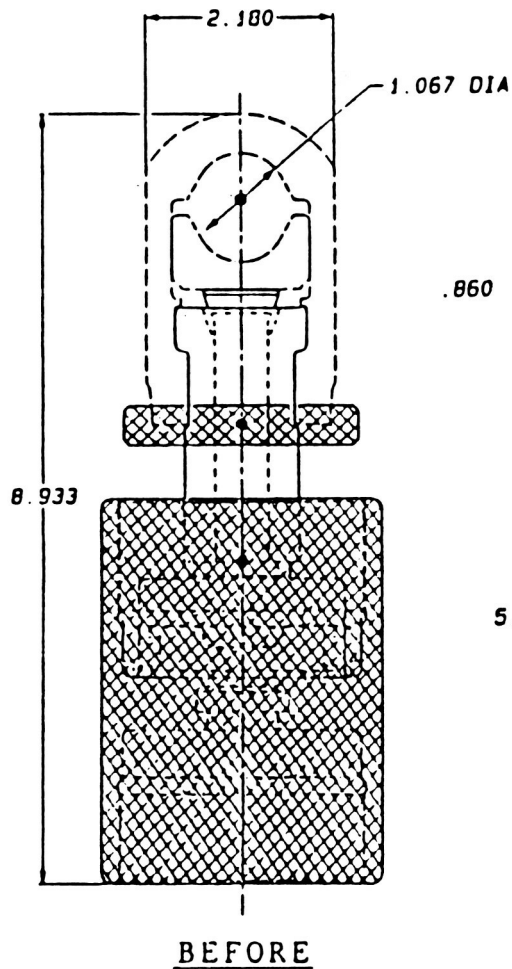
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DEUTSCH METAL COMPONENTS  
SCREW  
FOR CASE 100

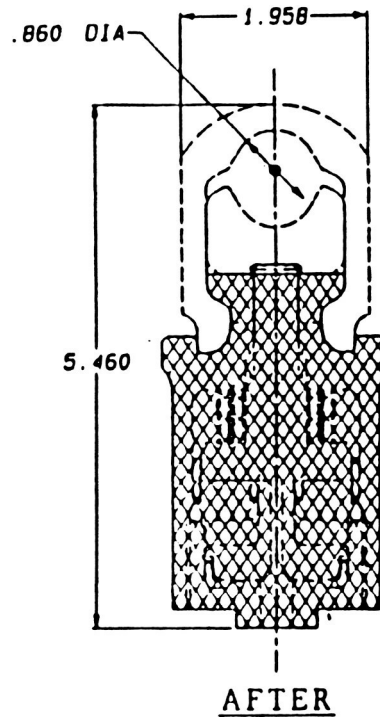
DISPLAY CONTROL? 1.PLOT 2.FILL HIDE 3.LABEL CONTROL 4.END

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WEIGHT 12.5 LBS



WEIGHT 4.0 LBS



## FINAL DESIGN

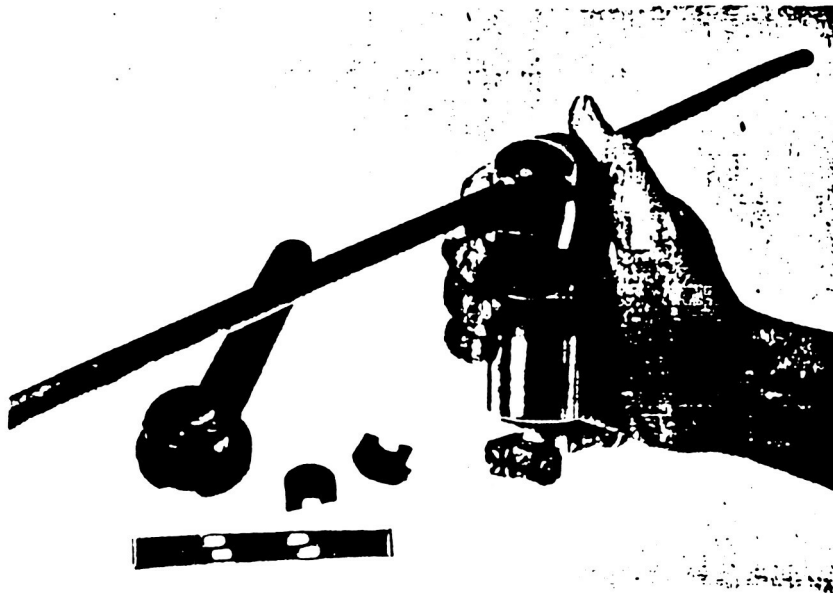
The above slide shows the "before and after" configuration after incorporating the aforementioned changes. The right hand slide shows the final design.

The 2 units shown have the same indentical swaging force and swage the same size fitting. The overall height had changed from approximately 10" to 5½". The cylinder diameter from 3.235 to 2.67 diameter. The head width from 2.180 to 1.958 and the weight from 12.5 pounds to 4.0 pounds.

The new design with its fewer and smaller parts has increased, in numerous areas, the profitability and producibility of this product line.

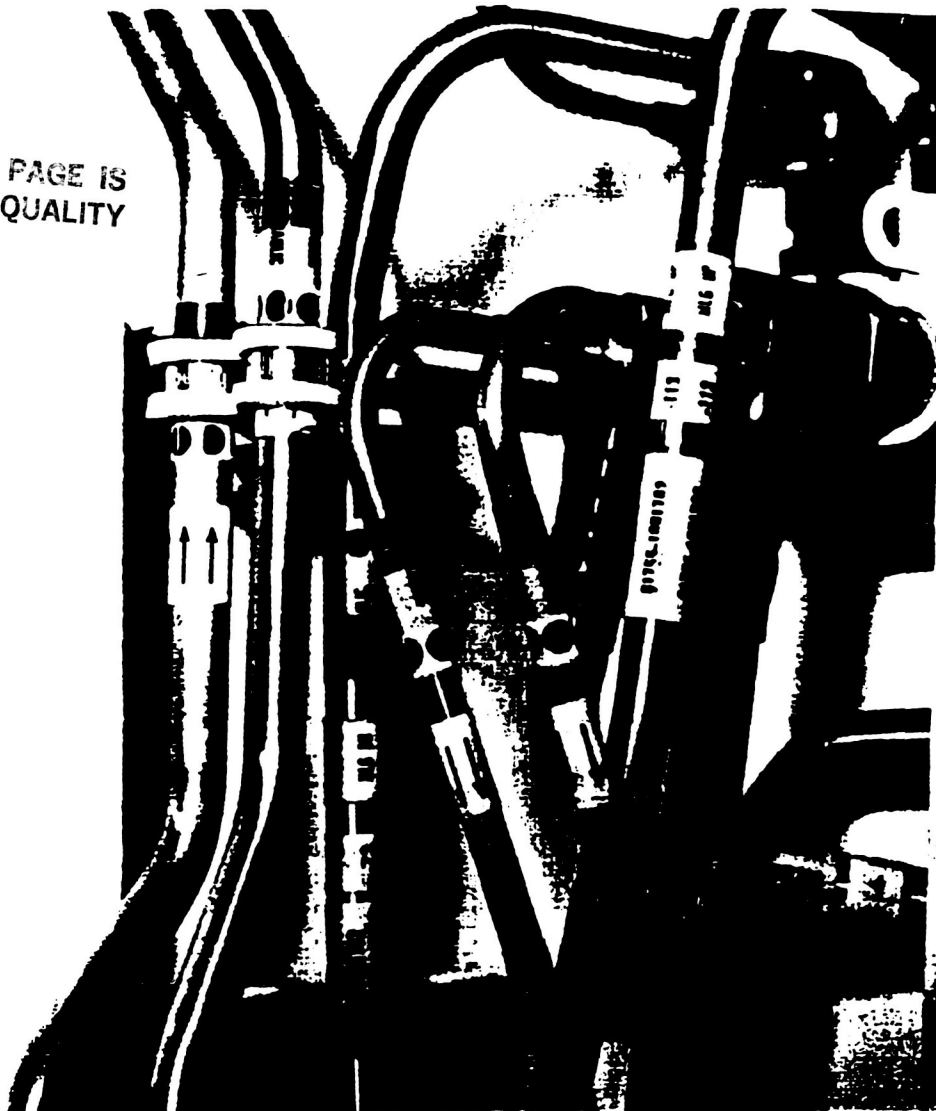


BEFORE



AFTER

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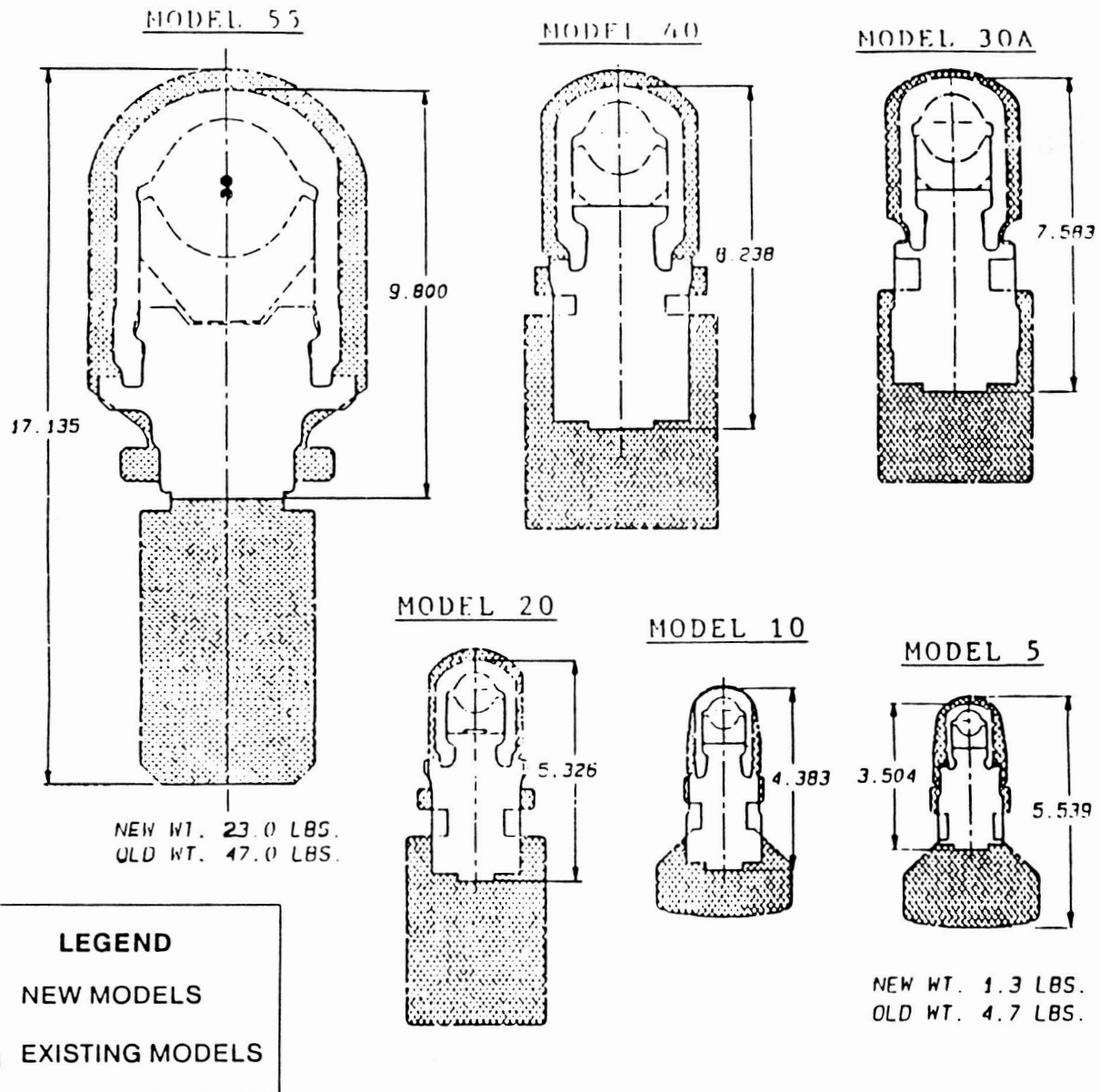


## IMPORTANCE OF SIZE & WEIGHT

This smaller size design which we were able to generate was very important to the marketing department. The smaller configuration allowed the tooling to perform the swaging operations in very confined and cramped areas such as would be found in military aircraft and piping banks aboard ship. While the original objective was to increase operational cycle life it soon became very evident that the smaller size and weight was a definite plus in marketing this product.

## ENGINEERING INNOVATIONS

Although, finite element analysis played a large part in accomplishing the design objectives there were some engineering innovations which also contributed to the success of this product. These items include the slide-on type head feature, the material selection, the tapered thread and the change from 5500 psi to 10,000 psi hydraulic pressure. All other changes were directly attributed to finite element analysis.



## COMPLETE PRODUCT LINE

The existing models are shown in the shaded area. The new models are shown in the white area within the shaded areas.

## SUMMARY

We started with the design objective to increase the operational cycle life of the Swaging Tool. To accomplish this increase in cycle life without increasing the size or weight of the tool would have been an engineering achievement. However, we not only increased the operational cycle life between 2 to 10 x but simultaneously we decreased the size and weight of the Swage Tool by about 50%. This accomplishment now becomes an outstanding engineering achievement.

This achievement was only possible because of the computerized Patran, Nastran and Medusa programs.

## **SOFTWARE & HARDWARE USED FOR PROGRAM**

The analysis shown in this paper was performed at the Deutsch Metal Components Division using the **Patran & Cosmic/Nastran** programs. The geometry was generated on Medusa Program and transferred to Patran for analysis. The computer used was a **Prime 2655**. Hardcopies of the finite element model and analysis results were obtained by Patran through a Tektronix 4115 terminal hooked to a Tektronix 4692 Ink-jet plotter.

## **REFERENCE:**

Loeckly, E.E., and Macke, H.I., "Effect of Taper on Screw-Thread Load Distribution." Transaction 74, A.S.M.E., 1952, pg. 103.